Debris Disks - LBTI

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Effect of Zodiacal Dust

Telescope Size	1 zody	3 zody	10 zody	30 zody
2 m	3.83	2.2	1.2	0.7
4 m	14.5	8.8	4.9	2.8
8 m	48.7	32.7	19.1	11.0

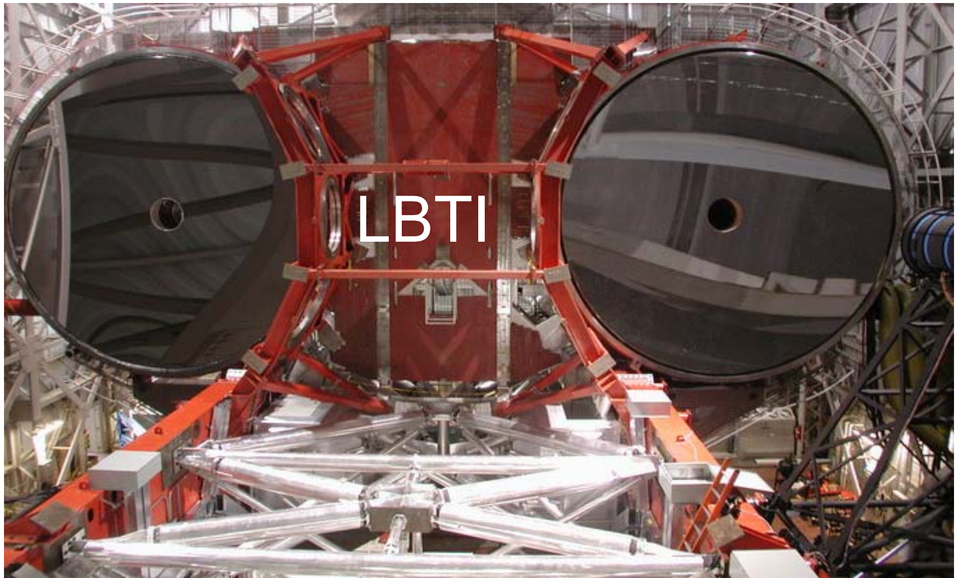
Table 1. Relative Signal to Noise performance for Optical Exo-Planet Imagers of different aperture size and exozody strength.

Element Size	1 zody	3 zody	10 zody	30 zody
1 m	3.8	3.5	2.8	2.0
2 m	13.5	10.7	7.1	4.4
4 m	39.5	26.5	15.5	9.1

Table 2. Relative Signal to Noise performance for IR Exo-Planet Imagers of different aperture size and exozody strength.

LBT has a unique combination of resolution and infrared sensitivity

- Sensitive to dust 0.7 AU from a star at 10 pc (0.07")
  - Dust in the habitable zone is well-matched to this resolution.
- System has only three warm reflections
  - Optimum infrared background, providing > 10x sensitivity advantage compared to long baseline interferometers
- Complementary to KI, Spitzer, and JWST



Status

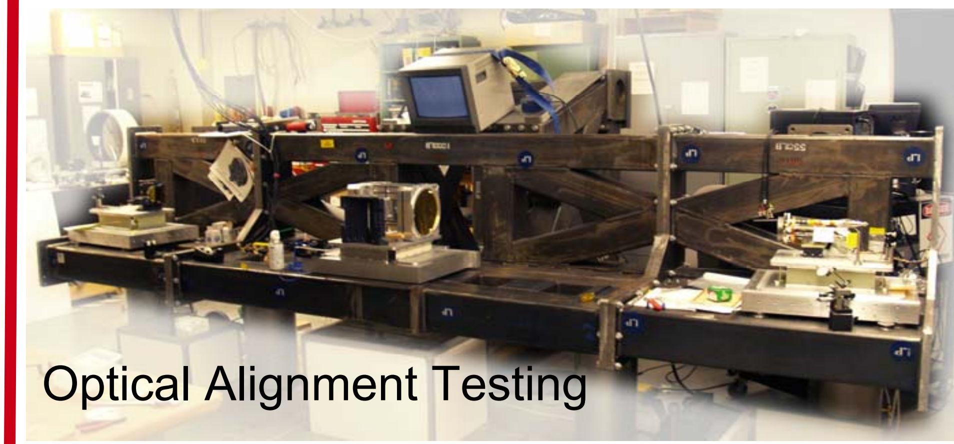
Large Binocular Telescope

- routine astronomical observations have begun.

Ready for Interferometry in late 2009

LBT Interferometer

- currently being tested in the laboratory.

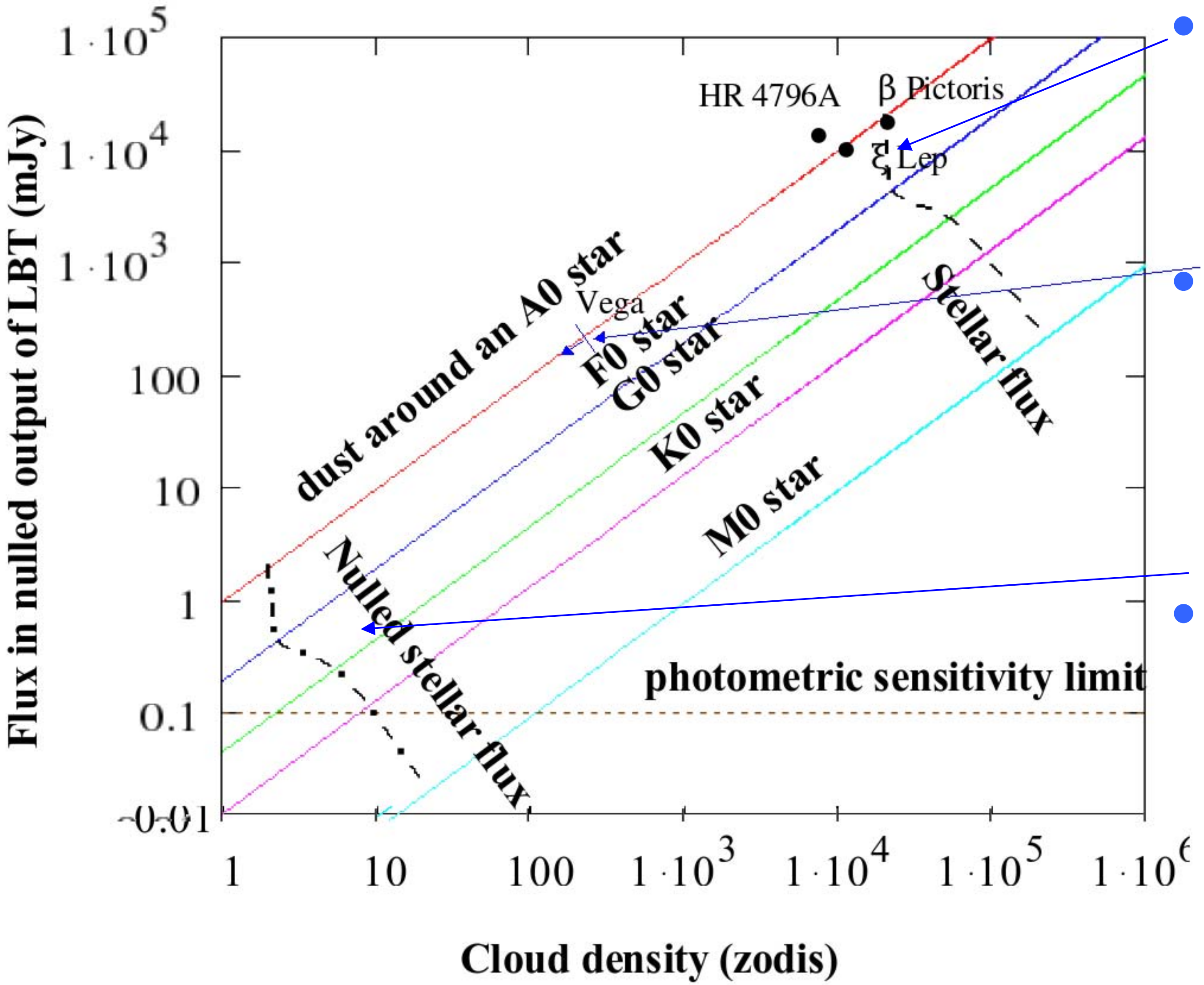


Optical Alignment Testing

Cryogenic Testing

- Telescope Integration starting in July 2008
- On-sky testing planned for 2009.

LBT projected debris disk limits



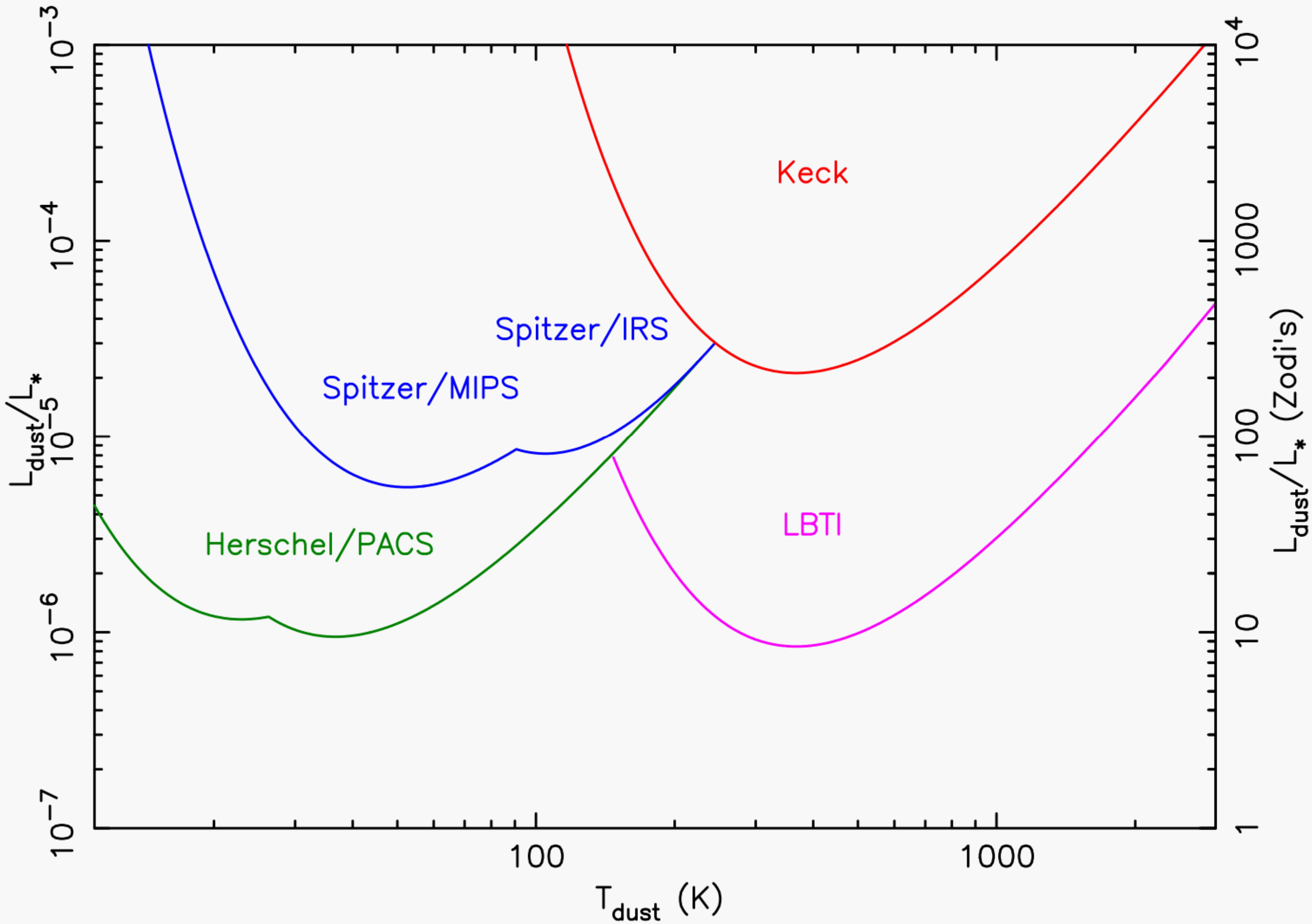
- Current ground-based observations can detect dust only when it is comparable to the stellar flux.
- Initial nulling observations with the MMT have allowed us to place a 3σ constraint of <500 zodies around Vega (Liu et al. 2004).
- LBTI will have improved photometric sensitivity and AO performance to allow detection down to ~10 zodies

Current and extrapolated performance

- AO performance with nulling tests at the MMT is a null uncertainty of 0.07% (20 zodies)
- Actual observed null variations are ~0.1% (night dependent)
- Star-to-star uncertainty is ~0.3% (80 zodies)

- Extrapolated null uncertainty when scaled to the LBT is 6 times better.
- Expected null uncertainty is 0.012% (3 zodies)
- If factor of 3 calibration uncertainty continues we would have an uncertainty of 12 zodies.

Detectability Comparison



JWST Capabilities

NIRCam: Disks seen in scattered light at new wavelengths; ices?

Coronagraphy: Multi-filter, 2 – 5 μm, *r*=0.4”, 0.6”, 0.8” spots, *r*=0.1”-0.8” wedges

MIRI: Disk seen in thermal emission (7x better resolution than Spitzer)

Imaging: 5.6 – 25.5 μm

Coronagraphy: Narrowband 10.65, 11.4, 15.5 μm (4 quad phase mask),

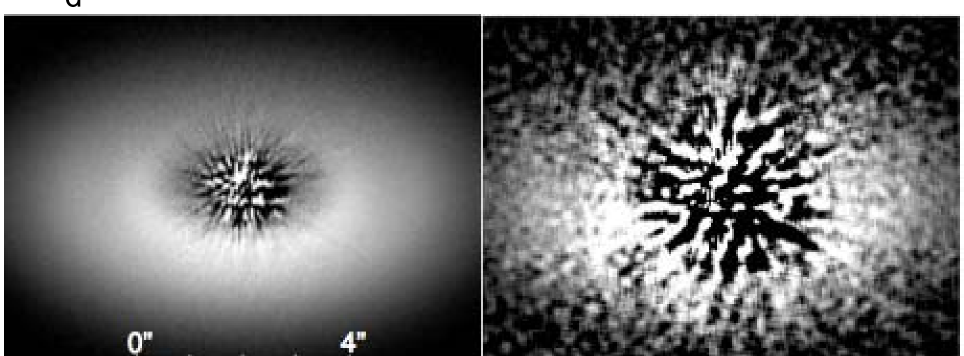
Broadband 20 – 24 μm (spot occulter)

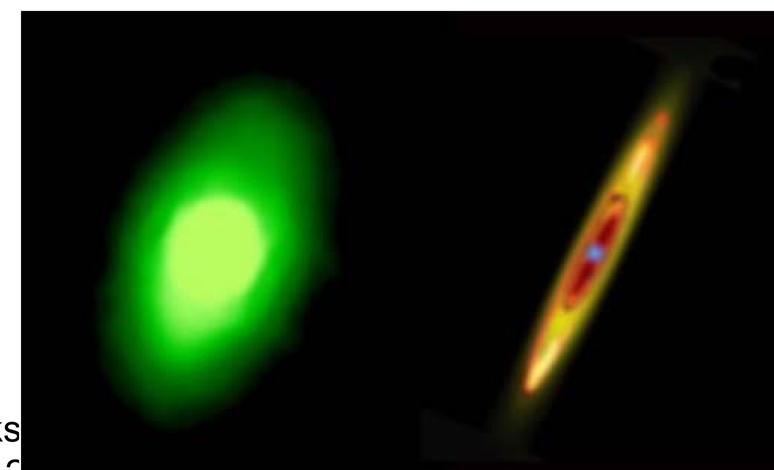
Spectroscopy: 5 – 11 μm (slit; R=100), 5 – 29 μm (IFU; R=2000-3700)

Fomalhaut

NIRCam Coronagraph 2.1 μm

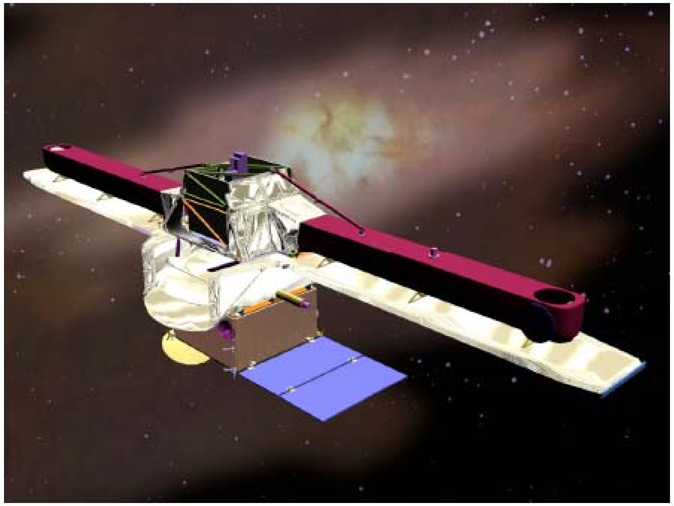
L_d/L_*= 8 x 10^{-3} 2 x 10^{-4}



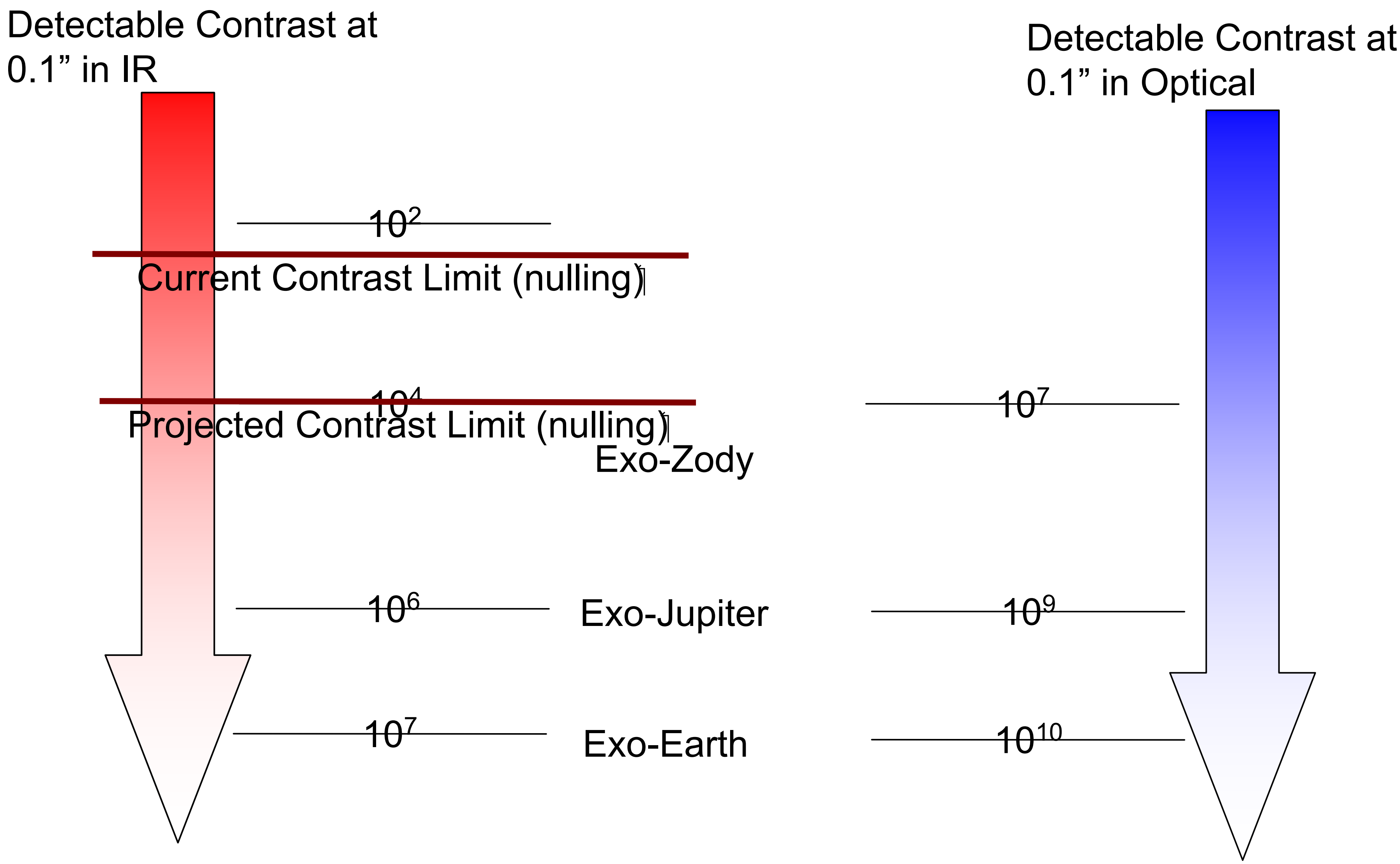


Possible Space Missions

- A small scale coronagraph or interferometer would aid in our understanding of debris disks.
  - More sensitive than ground observations.
  - Could detect structure in disks, indicative of planets.



Rationale for small-scale missions



Disk Chapter Recommendations

- Since information about dust in the habitable zone is crucial to planning future direct detection missions, the continued support of KI, LBTI, and any additional efforts that can address this question is needed to maintain momentum in this area.

- Small-scale missions that can address the density and distribution of dust in other planetary systems should be further studied to understand how they may complement or extend ground-based efforts. A small scale dust and giant planets mission may make follow-on terrestrial planet missions more secure.

- A robust theory program and development of collisional debris disk models will aid in decoding the resonant structures induced by planets in observed debris disks. These models will give insight into dust transport and may guide estimates of exozodiacal emission.